Space Weather Technical Forecast

From the 24th of September, the way we distribute this forecast is changing and you will need to take action to continue receiving it. You should have received an email on the 4th of September explaining the steps required to do this. If you have already signed up to receive the forecast on our premium website, please disregard this message. If you haven't, or if you need help with the process, please contact moswoc@metoffice.gov.uk

Issued on Wednesday, 11 September 2024 at 13:05 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

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Space Weather Forecast Headline: G1-G2 storm expected, possibly G3, on Friday 13 September. Slight chance of S1 minor radiation storm throughout.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Activity as measured by GOES16 and 18 has been Moderate, with a peak flare of M1.6 at 10/1547 UTC from Ex-3808, which has rotated just beyond the west limb.

There are currently ten sunspot regions on the visible disc, two of which are unnumbered. Most of the active regions are now on the western hemisphere and appear to be relatively simple and stable. The largest and most complex region is AR3814, which is north centre disc. This region recently lost its delta configuration but remains magnetically unstable based on satellite imagery. It continues to display a slight growth, with the addition of a tiny spot with umbra on its southern flank and remains the most likely source of flare. The region immediately east of this, AR3822, appears weaker, with the loss of a couple of spots on its trailing portion. The most significant growth belongs to the new region near the solar equator in the east. It is still relatively small and has been classified as Cro/Beta.

No Earth-directed CMEs have been observed during the period. Coronagraph imagery showed a south-heading CME originating from a small filament eruption. There is a significant amount of filaments present on the western hemisphere; any lift-off would probably be Earth-directed given their location on the sun.

Solar Wind / Geomagnetic Activity: The solar wind measured by ACE at L1 indicated a return to a slow regime. The solar wind speed fluctuated between 380-420 km/s initially but decreased down to 340-360 km/s later in the period. Density remained well below average. The phi angle was largely negative (towards the Sun) but switched to positive (away from the sun) since 11/0900 UTC. The Interplanetary Magnetic Field (IMF), Bt was weak and slowly decreased from 7 to 4nT, the north-south component becoming equally weak and largely positive. The net result of the above solar wind measures was for Quiet geomagnetic activity (Kp 1-2).

Energetic Particles / Solar Radiation: High energy (greater than 10 MeV) proton flux observed by GOES18 continually decreased during this period, eventually returning to moderate levels in the early UTC hours of the 11 Sep.

High energy electron flux (greater than 2MeV) observed by GOES16 was at background levels. The associated 24-hour fluence remained below the Active threshold, with 1.48e6 integrated pfu observed at 10/2359UTC.

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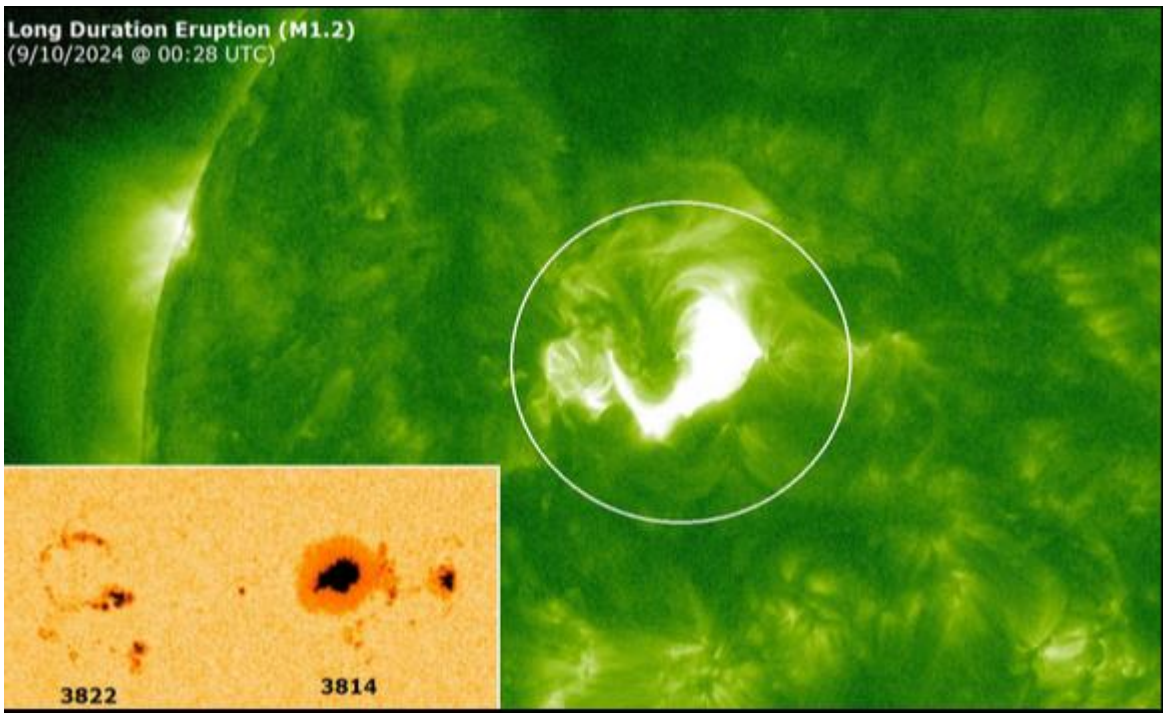
Four-Day Space Weather Forecast Summary

Solar Activity: Moderate activity is Likely to continue throughout, with a daily Slight Chance of X-class flares. The complexity and flare risk of oncoming sunspot regions is likely to exceed that from any departures through midweek UTC, and the overall risk is upwards around this time.

Solar Wind / Geomagnetic Activity: Two Earth-directed CMEs were in the initial forecast. The first one is largely overdue and can now be dismissed. The second one followed an M1.2 flare early on 10 Sep, expected to arrive late on Day 2 (12 Sep) or early on Day 3 (13 Sep). Enlil is currently offering a reasonable representation of solar wind conditions, and it is felt correct in delaying any fast wind arrival from CH68/- till the end of Day 4 (14 Sep).

Figure 0: HMIIF and AIA0094 imagery of the Active Region (AR3814) responsible for the M1.2 flare that preceded the aforementioned CME.



On balance, Quiet to Unsettled conditions should persist for much of Day 1 and Day 2 (11-12 Sep), followed by an increasing risk of G1-G2/Minor-Moderate Storms early on Day 3 (13 Sep) with a slight chance of G3 / Strong Storm interval. The CME impacts probably lingering into Day 4 (14 Sep), with further Unsettled or perhaps Active intervals.

Energetic Particles / Solar Radiation: A heightened risk of flare activity brings a daily chance of reaching/exceeding the S1 Minor Radiation storm level, should any significant flares occur from active regions in the western hemisphere. High energy electron flux is expected to remain near current Normal Background levels throughout, with Active 24-hour fluence not expected.

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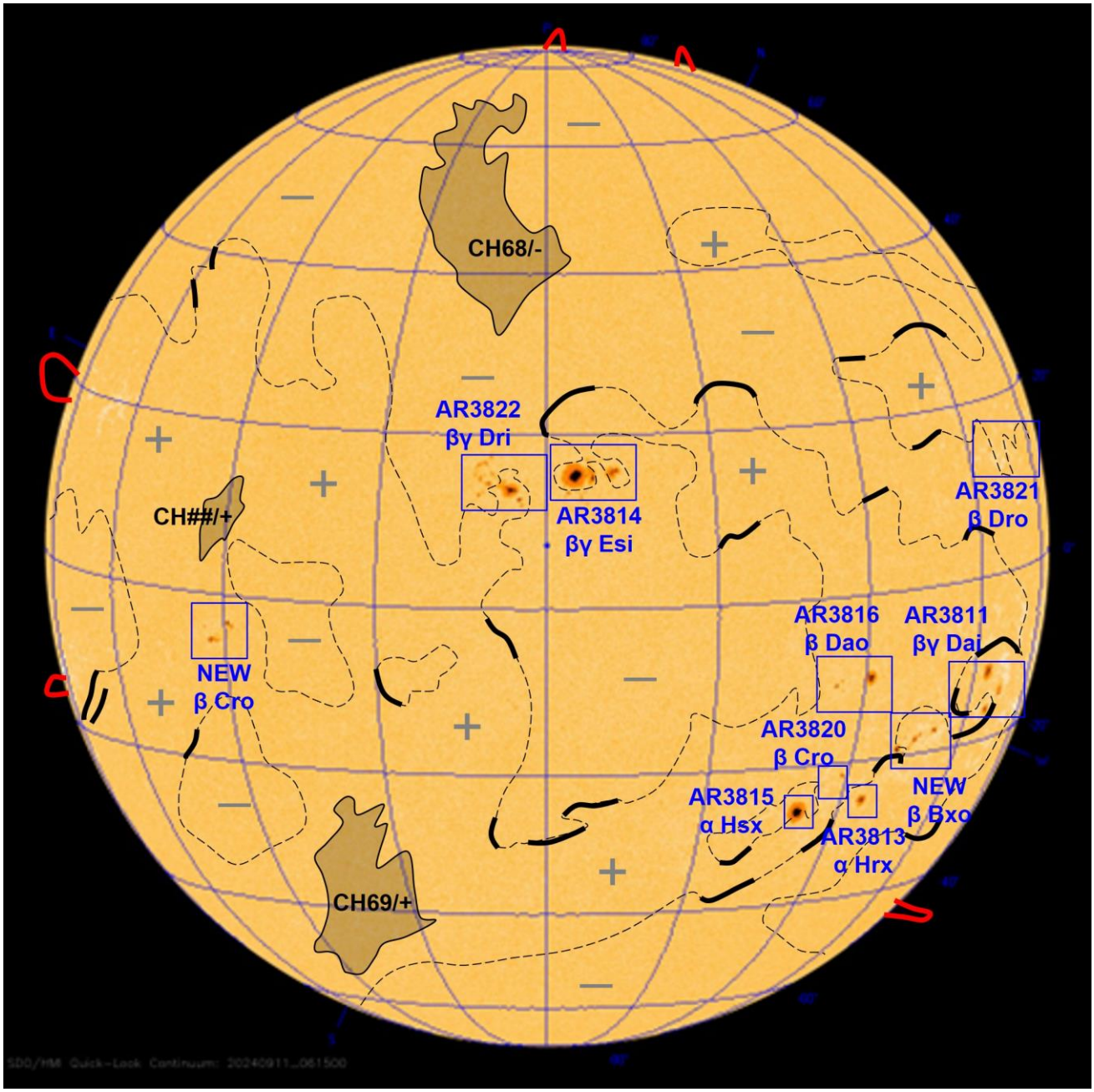
Figure 1. Solar Analysis Valid 11/0800 UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Met Office Space Weather Technical Forecast

Geomagnetic Storms:

There were two Earth-directed CMEs in the initial forecast.

A partial halo CME associated with a large filament eruption off the northwest quadrant, near Ex-3812, produced a Type II radio emission, with a speed of 924km/s. This has been analysed as potentially giving a glancing blow at Earth early on 11 Sep, although the bulk of the plasma material appears to be going to the west of Earth. Stereo A Mag & Plastic data showed a slight enhancement at around 11/0050 UTC, perhaps indicating an arrival at the spacecraft. Being slightly ahead of Earth's orbit, an arrival at Earth is therefore largely overdue and very improbable.

A faint but full halo CME was also observed during the early UTC hours of the 10th, following the long-period M1.2 from AR3814. It also produced a type II radio emission with an estimated speed of 408 km/s. The analysis estimated its speed to be around 630 km/s, giving an arrival at Earth late on 12 Sep or early on 13 Sep. The effects of the CME may linger into the start of the UTC weekend.

There is a recurrent coronal hole (CH68/-) currently crossing the central meridian however, it has retrogressed by around a day (13 degrees) on this rotation, which would very likely put any minor 450km/s fast wind at the end of Day 4 (14 Sep) rather than Day 3 (13 Sep) , as is suggested by the SWPM.

On balance, Quiet to Unsettled conditions should persist for much of Day 1 and Day 2 (11-12 Sep), followed by an increasing risk of G1-G2/Minor-Moderate Storms early on Day 3 (13 Sep) with a slight chance of G3 / Strong Storm interval. The CME impacts probably lingering into Day 4 (14 Sep), with further Unsettled or perhaps Active intervals.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	5	1	60	20
Strong	G3	No	1	1	20	5
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
10/0526 UTC	Faint full halo	AR3814	NE	630 km/s	13/0600 UTC +/-9hrs	Limited shock expected

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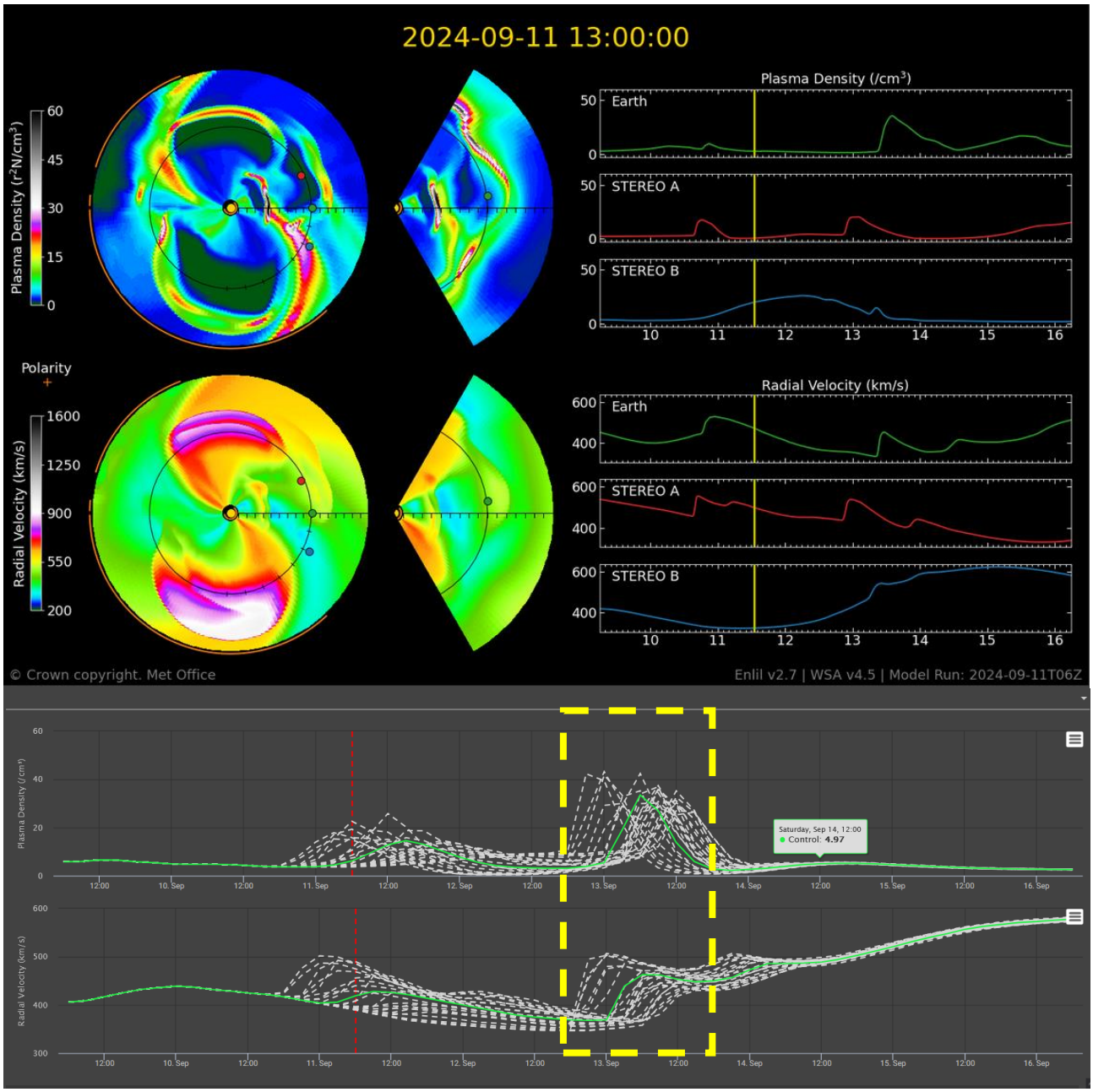
Figure 2: MOSWOC Enlil and Ensemble showing potential CME arrival on 13 Sep.



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Radio Blackouts - X-Ray Flares:
There are currently ten sunspot regions on the visible disc, two of which are unnumbered. Most of the active regions are now on the western hemisphere and appear to be relatively simple and stable. The largest and most complex region is AR3814, which is north centre disc. This region recently lost its delta configuration but remains magnetically unstable based on satellite imagery. It continues to display a slight growth, with the addition of a tiny spot with umbra on its southern flank and remains the most likely source of flare. The region immediately east of this, AR3822, appears weaker, with the loss of a couple of spots on its trailing portion. The most significant growth belongs to the new region near the solar equator in the east. It is still relatively small and has been classified as Cro/Beta.

The imminently arriving eastern solar horizon encompasses several large returning regions including Ex-AR3790, 92, 93 and 3802, i.e. those roughly between Carrington Longitudes 010 and 025. One of the northern hemisphere regions, perhaps 3802 was responsible for a large and energetic CME in the past 24 hours off the eastern limb, and was perhaps also responsible for noteworthy far-sided CMEs on 03 and 05 September. As well as this northern hemisphere feature, there appears to be a magnetic connection to the southern hemisphere cluster (for example, AIA171 imagery), and this part of the Sun returning to the facing side of the disc is therefore very likely to result in an upturn in daily flare risk.

With Ex-AR3806 rotating off the disc, there are no more departures expected until AR3811 and AR3821 follow suit by day 3, Friday 13 September. Given the likely complex arrivals due by midweek UTC, the overall risk of significant flares is upwards in the period, with M class Likely and a Slight Chance of X-class.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	Yes	50	60	70	70
Very Active	R3 to R5 X Class	No	10	10	15	15

Figure 3: Latest X-Ray flare activity, as observed at GOES-16 & GOES-18

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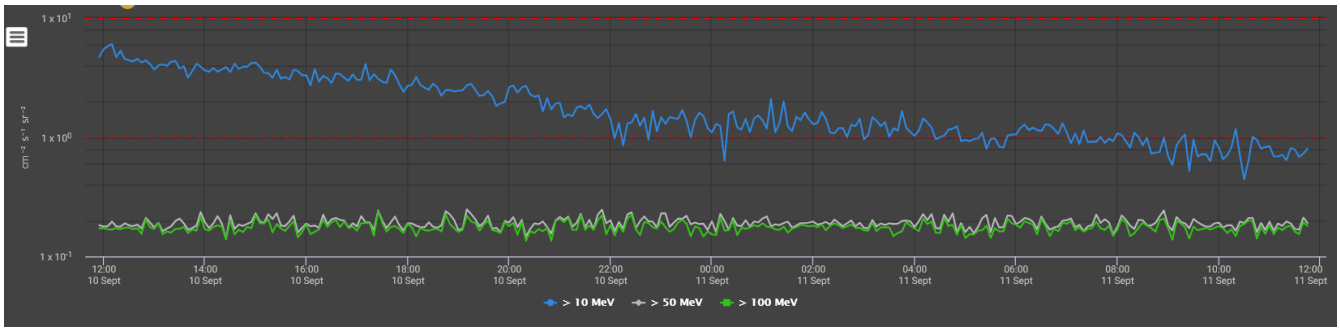
Solar Radiation Storms - (High Energy Protons):
High energy proton flux showed a gradual decreasing trend, eventually returning below the S1 / Minor Storm level around 10/0750 UTC after the enhancement prompted by the long-period 09/0333UTC M1.0 from Ex-3808. The flux is currently levelling off just below the S1 level and is expected to remain at this level over the next 24 hours.

Further chance of reaching the S1 Minor Radiation Storm threshold in the coming days, if any other significant flaring occurs from the cluster of active regions currently transiting across the southwest quadrant.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	Yes	20	20	20	20
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

Figure 4: Latest Proton Flux, as observed at GOES-18



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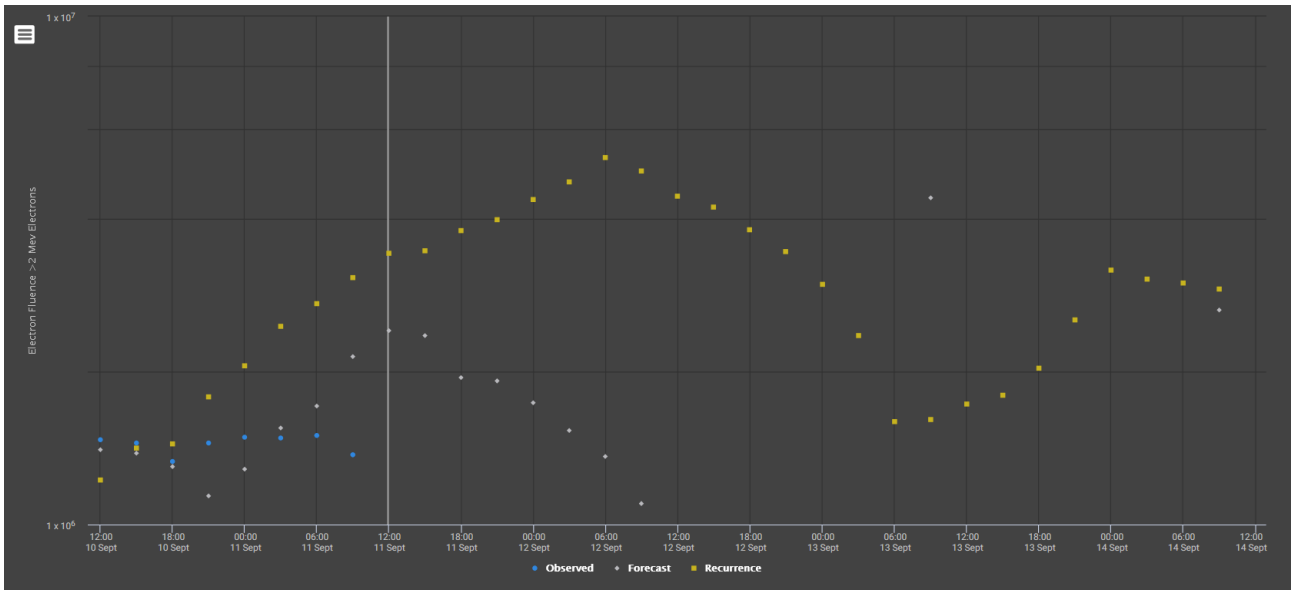
High Energy Electrons Event (≥ 2MeV):

The high energy electron flux is currently at background, with no fast wind likely to charge the Van Allen belts during this period. The 10 Sept CME (expected on Day 3) may be able to drive a minor increase on Day 4 but nothing significant enough to threaten the corresponding Active 24-hour fluence which remains well below threshold.
All considered, the chances of Active 24-hour fluence are very low throughout.

GEO Electron Environment	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	≥ 2 MeV ≥ $1x10^8$	No	1	1	1	1
Very Active	≥ 2 MeV ≥ $1x10^9$	No	1	1	1	1

Figure 5: Latest MOSWOC REFM output



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